PR-9. NOVEL NANO PHOSPHOR FOR SOLID STATE LIGHTING DEVICES

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The investigations on inorganic phosphate phosphors composed of a host lattice doped with a small amount of impurity ions (transition and rare earth ions) that activate luminescence come to be a burning issue in exploring new phosphor materials for practical applications. Inorganic $NaCaAlPO_4F_3$ (SCAPF) halophosphor is a Viitaniemiite type compound, contains various inorganic compounds such as alkali, alkaline earth, aluminum and fluorophosphates. The SCAPF phosphor has mono-clinic structure with the space group P21/m. The alkali and alkaline earth halo-phosphates are still consummate as a family of phosphor host-matrix. The low phonon energy of the halide phosphates hosts yields low non-radioactive decay and high radiative emission rates which makes them as the best potential host materials for several transition metal ions/rare earth dopants, which unravel the increasing need in optoelectronic and photonics applications.

The starting chemicals Na_2CO_3, $AlF_3.3H_2O$, $CaCO_3$, $(NH_4)_2HPO_4$ and transition metal oxide/rare earth oxide were taken in a requisite proportion. The mixture was grounded adequately in agate mortar and kept in a crucible for sintering by a three step heating process (650 °C for 8 hours, 700 °C for 4 hours, 750 °C for 2 hours) in high temperature muffle furnace Finally, the powder was taken out and grounded again to obtain TM/RE ions doped $NaCaAlF_3PO_4$ nanophosphors. To enable the reaction and to enhance the crystallinity of luminescent materials, flux agents were often added to provide a more supportive medium for solid state reaction. To moderate the reaction temperature and regulate the particle growth, fluxes such as metal fluoride (AlF_3 or MgF_2) were also used. Here the flux $AlF_3.3H_2O$ was used to improve the phase purity and control the particle size of nanophosphor.

The present talk deals with the undoped and transition metal ions (VO^{2+}, Cr^{3+}, Mn^{2+}, Fe^{3+}, Co^{2+} and Cu^{2+} ions) and rare earth ions (Sm^{3+}, Dy^{3+}, Pr^{3+} and Er^{3+}) doped $NaCaAlPO4F_3$ (SCAPF) nanophosphors are prepared as mentioned above and their characterisation (XRD, Optical, SEM, TEM, EPR, FT-IR and PL) for novel solid state lighting devices. The powder XRD results confirm the crystal structure of prepared samples has monoclinic system and are in good agreement with the standard pattern of $NaCaAlPO_4F_3$ (Viitaniemiite). The slight variations are observed in lattice cell parameters which may be due to the presence of TM and RE ions in the host lattice. The average crystallite sizes of transition metal and rare earth ions doped SCAPF nanophosphors are in the range of 40–90 nm. SEM images shows nanoclusters and particles with irregular morphologies and agglomeration was observed due to high temperature involved in the synthesis of phosphor material. EDS spectrum confirms the presence of Na, Ca, Al, F, P, O and TM ions in the prepared nanophosphor materials. FT-IR spectra of all the transition metal ions and trivalent rare earth ions doped SCAPF nanophosphors exhibited the fundamental vibrations of PO_4, P-O-H, F-P-F and water molecules. Slight shifting of band positions is observed due to change in ionic radii of trivalent rare earth ion dopants. Optical absorption spectra of the TM and RE ions doped SCAPF nanophosphors show significant characteristic peaks related to d-d and f-f transitions. From optical and EPR studies, the crystal field, tetragonal field and racah parameters are evaluated for TM ions doped nanophosphors, and the site symmetry, bonding nature of the dopant ions are also identified. J-O parameters are determined for RE ions doped SCAPF nanophosphors which reveal bonding nature, site symmetry around the active ion, rigidity etc. Photoluminescence spectra of TM and RE ions doped $NaCaAlPO_4F_3$ nanophosphors exhibited various bands between UV to VIS regions. TM ions and RE ions doped SCAPF nanophosphors exhibited different colour emissions in different regions like blue, red, yellowish-green, near white etc. Among the prepared all the samples host lattice and TM and RE doped nanophosphors are suitable for low cost solid state lighting devices.